National Personal Protective Technology Laboratory

HEALTHCARE WORKER UNIVERSAL PRECAUTIONS INTERFACES AND ASSOCIATED ISSUES

Raymond Roberge, MD, MPH

Research Medical Officer, NIOSH/NPPTL

March 2-3, 2010

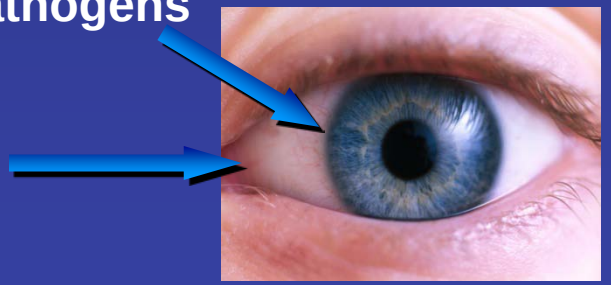
"UNIVERSAL PRECAUTIONS"

- ***Universal Precautions*** **refers to the practice, in medicine, of avoiding contact with patients' bodily fluids, by means of wearing of nonporous PPE such as gloves, gowns, respirators, surgical masks, goggles, and face shields. The assumption is that all bodily fluids are potentially infectious and must be so treated.**

- **Standard Precautions apply to 1) blood; 2) all body fluids, secretions, and excretions, *except sweat*, regardless of whether or not they contain visible blood; 3) non-intact skin; and 4) mucous membranes.**

"EYEMERGING" INFECTIOUS DISEASES

- **Under Occupational Health and Safety Act (OHSA) Standards 29CFR "masks in combination with eye protection devices, such as goggles, glasses with side shields or chin length face shields shall be worn whenever splashes, spray, splatters or droplets of blood or other infectious materials may be generated and eye, nose or mouth contamination can reasonably be anticipated."**
- **No definitive study to address ophthalmic exposure when the aforementioned mechanisms are absent, but risk is considered minimal (Buckland and Tyrrell, 1964)**
- **Affinity of ophthalmic receptors for various viruses may be important limiting factor for some pathogens (e.g., Avian influenza)**
- **Nasolacrimal duct function is important for infectious agents w/o significant binding to ophthalmic receptors**



HOW IMPORTANT IS FACIAL PROTECTION DURING SURGERY?

- **50% of caesarean sections and 32% of vaginal deliveries associated with measurable contamination of the face shield surface that was not detected by the physician (Kouri and Ernest, 1993)**
- **Polycarb glasses worn by surgical team members were contaminated in 62% of orthopedic cases (Giachino et al, 1988)**
- **Face shield contamination was documented in 33% of facial dermatological surgical procedures (Birnie et al, 2007)**

HEALTHCARE WORKER EYE PROTECTION COMPLIANCE/CONCERNS

- **32% wore regular spectacles during surgery and 24% wore no eye covering of any kind (Akduman et al, 1999)**
- **10% of emergency department and ICU staff reported never wearing eye protection (Bryce et al, 2008)**
- **Reasons cited for lack of wear (Lombardi et al, 2009; Greenland et al, 2007; Hutcheon, 2004):**

  -lack of comfort/fit

  -fogging

  -scratching of eyewear

  -interference with medical procedures (e.g., fibreoptic intubation, operative loops, etc.)

  **-claustrophobic sensations **

HEALTHCARE WORKER EYE PROTECTION

- **Goggles, glasses, face shields, visors**

(courtesy 3M)

EYE PROTECTION/RESPIRATORY PROTECTION INTERFACES

With permission – Canadian Journal of Anesthesiology

SURGICAL GLOVES

- The most used HCW PPE
- Helps prevent transmission of infectious agents
- Innovative uses:

  -increased grip when performing some procedures (e.g., shoulder reduction).

  -can be used as a tourniquet

  -can be used as an ice bag

  -can be used to make pediatric playthings (Mr. Fingerhead)

Courtesy of Dermatology Online Journal

SURGICAL GLOVES - ISSUES

- Limit mobility.
- Alter the sense of touch.
- Decrease agility with some delicate procedures.
- Size issues:
  - -gloves that are too large for the individual allow finger slippage leading to decreased dexterity
  - -gloves that are too small cause discomfort (decreased blood flow to fingertips; pulling on hand and digit hair) and constrain finger and hand movements
- Become entangled in some instruments
- Friction from gloves against the skin can make some procedures more difficult (e.g., inserting an IV)
- Allergy concerns (latex)
- Overuse can lead to decreased hand washing

GLOVE/SLEEVE INTERFACE

- **“Roll Down” – slippage resulting from low frictional resistance between the glove inner surface and the gown sleeve increases risk of body fluid contamination.**
- **“Channeling” – as a result of the glove being pulled over the sleeve, the sleeve is bunched up under the glove and forms channels along the wearer’s wrist that may allow body fluids running down the outside of the sleeve to gain access to the interior of the glove.**
- **Taping may not be effective because the adhesives are subject to attack by water and body fluids.**

Zamora, J. E. et al. CMAJ 2006;175:249-254
Courtesy of CMAJ

POWERED AIR-PURIFYING RESPIRATOR INTERFACES

- **Visual interface – use of other concurrent eye protection**

With permission – Canadian Journal of Anesthesiology

- **Equipment interface– use of stethescope, ophthalmoscope, fibreoptic bronchoscope, etc.**

Courtesy of Bullard

- **Dermal interface – use of shrouds**

Zamora, J. E. et al. CMAJ 2006;175:249-254 Courtesy of CMAJ

FFR PHYSIOLOGICAL INTERFACES

- **Phase I - N95 FFR and N95 FFR/EV vs Controls (no FFR) treadmill exercising at 1.7mph and 2.5 mph x 1 hr:**
- **No significant differences in HT, V_T, V_E, SaO_2, $tcPCO_2$ for controls versus FFR or FFR/EV at either work rate x one hour.**
- **Slight increase (not statistically significant) in V_T (range, 38 mL – 148 mL) with respirator use**
- **No significant difference in mean mixed inhalation/exhalation $V_{D\ resp}$ CO_2 (2.86%, 2.92%[p=0.47]) and O_2 (16.62%,16.68% [p=0.30]) values with respirator use x one hour**
- **tcPCO2 increases (non-significant) were: 0.54/1.26 mm Hg at 1.7/2.5 mph, respectively, for N95 FFR/EV, 1.22 mm Hg for N95 FFR at 2.5 mph and -.72 mm Hg at 1.7 mph for N95 FFR (2 subjects > 50 mm Hg)**
- **No difference in comfort & exertion scores, or moisture retention**
- ***Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ. (2010) Physiological impact of N95 filtering facepiece respirator ("N95 Masks") use on healthcare workers. Respiratory Care (in press)***

FFR/SURGICAL MASK PHYSIOLOGICAL INTERFACES

- **Phase 2 - N95 FFR and N95 FFR/EV vs N95 FFR/SM and N95 FFR/EV/EM treadmill exercising at 1.7mph and 2.5 mph x 1 hr:**
- **No significant differences for N95 FFR/SM and N95 FFR/EV/SM compared to standard models, for HR, f_B, V_T, V_E, SaO_2 x one hour.**
- **Compared with controls, significant decrease in $V_{D\ resp}$ oxygen levels with N95 FFR/SM at 1.7 mph (p=0.03) and for N95 FFR/EV/SM at 2.5 mph (p=0.003).**
- **Two subjects had elevated tcPCO2 levels (48,60)**
- **No significant differences in comfort & exertion scores, or moisture retention**

Roberge RJ, Coca A, Williams WJ, Palmiero AJ, Powell JB (2010) Surgical mask placement over N95 filtering facepiece respirators: physiological effects on healthcare workers. Respirology (in press)

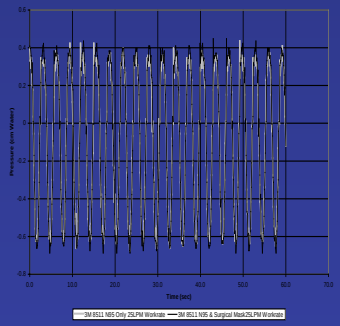
EAPR PHYSIOLOGICAL INTERFACES

- **Phase 3 – elastomeric half facepiece air-purifying respirator vs control (no respirator) treadmill exercising at 1.7mph and 2.5 mph x 1 hr:**
- **No significant differences in HR, SaO_2, and $tcPCO_2$ x one hour compared with controls**
- **Significantly lower f_B associated with elastomeric respirators at both work rates (p=0.02, p=0.03, respectively)**
- **Significant decrease in V_T at 1.7 mph compared with controls (p=0.009)**
- **Half of subjects at each work rate had elevated $tcPCO_2$ levels (• 45 mm Hg) at the one hour**
- **No significant differences in comfort & exertion scores, and moisture retention.**

- ***Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ. (2010) Reusable elastomeric air-purifying respirators: physiological impact on healthcare workers. American Journal of Infection Control (in press)***

FFR/SURGICAL MASK INTERFACE AND BREATHING RESISTANCE

- **Human surrogate: breathing mannequin/headform (Smartman, ILC Dover, Frederica, DE) attached to a Dynamic Breathing Machine (Warwick Technology, Ltd., Warwick, UK) that delivered sinusoidal breathing patterns at 25 L/min and 40 L/min.**
- **Room particle counts: 16,000 – 30,000 m^3 by a TSI Particle Generator (TSI, Shoreview, MN).**
- **Respirators: NIOSH-certified N95FFRs (3 replicates x 3 models; different manufacturers) were individually heat-glued to the mannequin and Protection Factors* (• 100 @ 25 L/min) quantified by TSI Portacount Plus® particle optical density measurement.**
- **Breathing resistance: Inhalation and exhalation breathing resistance was measured with an in-line Validyne Variable Resistance Pressure Transducer Model DP45-24 (Validyne Engineering Corp, Northridge, CA) for 774 inhalations and 774 total exhalations.**
- **Surgical mask overlay: a non-splash resistant, Type II surgical mask model (single manufacturer) was applied over the respirator and pressure measurements repeated and compared.**



SURGICAL MASK-N95FFR COMBINATION: BREATHING RESISTANCE RESULTS SUMMARY

Increases in Breathing Resistance

N95FFR MODEL	% inhalation resistance increase @ 25 L/min	% inhalation resistance increase @ 40 L/min	% exhalation resistance increase @ 25 L/min	% exhalation resistance increase @ 40L/min
A	10.09	12.61	12.30	13.22
B	7.61	8.99	8.56	9.58
C	4.60	6.03	5.79	3.44
Mean	6.99	8.70	8.43	9.48
N95/exhal. Valve	4.64	4.84	9.11	10.36

RESPIRATOR MICROENVIRONMENT INTERFACE

- **OSHA workplace ambient air standard (respirator not factored into determination)**
  - **- CO_2 < 0.5%**
  - **- O_2 <19.5% is considered deficient**

Mean Respirator Deadspace Gas Centrations After Treadmill Exercise X 1 hr

Respirator	Mixed inhalation/ exhalation O_2 concentration	Mixed inhalation/ exhalation CO_2 concentration
N95 FFR	16.63%	2.86%
N95 FFR/EV	16.68%	2.92%
N95 FFR/SM	16.43%	2.97%
N95 FFR/EV/SM	16.48%	2.97%
EAPR	17.83%	2.48%

MOISTURE INTERFACE - AMBIENT HUMIDITY, SWEAT AND EXHALED MOISTURE

- **Test Procedure – Automated Breathing and Metabolic Simulator, and attached breathing mannequin with affixed N95 FFR, N95 FFR/EV, and SN95 FFR (9 models, 45 respirators), programmed at 100% humidity, 34º C exhaled air, 40 LPM breathing volume X four hours. Controls were the first five minutes of ABMS breathing. Ambient temp. 22.3 C, RH 40 – 60%.**
- **Outcome measures: inhalation resistance, exhalation resistance, FFR moisture retention**
- **Results**

- mean inhalation resistance increase from -14.11 mm to -14.54 mm H_2O pressure (increase of -0.43 mm)

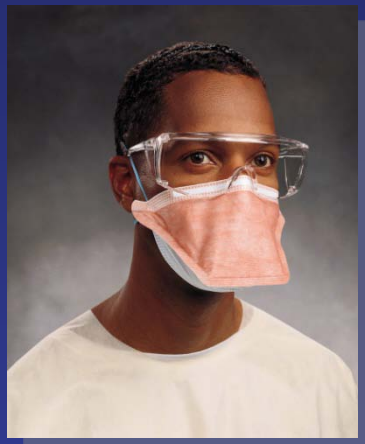
-mean exhalation resistance increase from 7.09 to 7.32 mm H_20 pressure (increase of 0.23 mm)

-mean moisture retention after 4 hours was 0.26 ml (~0.02% of total expired water vapor)

-a significantly lower exhalation resistance was noted for N95 FFR compared with SN95 FFR after four hours (p=0.007); otherwise, no significant differences were noted between FFR classes

Roberge RJ, Bayer A, Powell JB, Coca A, Roberge MR, Benson SM: Effect of exhaled moisture on breathing resistance of filtering facepiece respirators. Ann Occup Hyg (under review)

Quality Partnerships Enhance Worker Safety & Health

Visit Us at: www.cdc.gov/niosh/npptl

Disclaimer:

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

Thank you